BELLCOMM, INC.

SUBJECT: Possible Use of Flares to Relax Lighting Constraints for Lunar Landing - Case 340

DATE: February 28, 1967

FROM: F. G. Allen
R. W. Newsome, Jr.

ABSTRACT

It is concluded that chemical flares will not be useful in relaxing the present sun-angle constraints for Apollo LM daylight landings. The illumination provided by a high-yield 100-pound 20-second flare would be comparable to sunlight only over a region within approximately 300 feet from the landing site. It might be useful for night landings.

(NASA-CR-154374) POSSIBLE USE OF FLARES TO RELAX LIGHTING CONSTRAINTS FOR LUNAR LANDING (Bellcomm, Inc.) 5 p

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MEMORANDUM FOR FILE

The question has been raised as to whether the use of flares to illuminate the lunar surface during daylight landing could significantly relax the present sun angle lighting constraints. A brief analysis indicates that the flare would be of little or no help. The analysis can be briefly summarized as follows:

We assume (1) A spacecraft descent angle of approximately 17°, with the sun shining from behind and making an angle with the horizon between 0 and 60 degrees;[1,2,3,4,5] (2) A one hundred pound flare that burns for twenty seconds delivering as visible light 50% of the total chemical energy available with chlorine tri-fluoride (CTF)[7]. (This assumes burning at a power level of about 15 megawatts, delivering a total energy of about 100 kilo-watt-hours).

The twenty second duration has been chosen as a rough compromise between high intensity illuminations for short times, and a sufficient time for an astronaut to observe details, make a decision and initiate a c hange of course.

To calculate illumination, the optimum position for the flare must be decided. Due to glare from the LM windows, the flare cannot be ahead of or above the spacecraft. Clearly, it should also be as close to the landing site as possible. Its best position is beneath the LM at a distance to make the illumination angle, measured from the horizontal, about 4° less than the viewing angle. This gives the best compromise between maximum reflected light (which peaks sharply when the backscattered ray is directly along the illuminating ray), and a contrast "wash out" that occurs at and near this peak reflection, (for illumination angles from about 4° below to 30° above the viewing angle 2,3,4,5,6). Since the viewing angle under present flight plans increases from the initial descent angle (17°), several miles from touch-down, up to about 60° at 300 feet (which is the last point at which the landing site will be visible[2,3]), the optimum illumination would result by suspending the flare on a cable about 100 feet directly beneath the spacecraft. Detailed considerations might lead to breaking up the single flare into several smaller ones, set off at intervals along the descent, and perhaps on either side of the LM. Such tactics appear to offer only marginal improvements, if any.

[redacted]

With these assumptions, we find that reflected sunlight from the lunar surface swamps out flare light, for sun angles between 3° and 60°, unless the flare is within about 300 feet of the area being examined. This is too small an area, and its illumination will occur too late, to permit a significant choice of site by the astronauts. It might assist the astronauts by providing a last-minute enhanced view of the surface details before landing.

For sun angles of a few degrees, parts of desirable landing areas (which may be inclined up to 7°) will be in shadow. The flare could relieve this shadowing somewhat; however solar illumination on horizontal surfaces will still be brighter than the flare "illumination" until the spacecraft is within a few hundred feet from the touch-down point.

For landing in darkness, the flare could provide an illumination of from about 30 times full moonlight at 10,000 feet, to about 750 times full moonlight (approximately the illumination level of twilight on Earth) at 2000 feet from touch-down. These levels will only be about 1/10 as effective on the moon as on earth due to the low albedo of the lunar surface. Dark adaptation of the astronauts' eyes may then be a problem if the site is near the dawn terminator, since they will have come from the daylight side.

It should be stressed here that a 50% light yield spread over 20 seconds has been assumed, whereas only about 1% yield during a few milliseconds has yet been achieved in vacuum. (Flares suffer a severe drop of efficiency at low pressures[8,9]). Considerable development will thus be required before these conditions can be met.

Conclusions

Use of a flare of reasonable weight will not relieve the present landing constraints imposed by sun illumination angles. It could assist only in enhanced detail viewing of the surface just before landing in daylight. If landing at sunrise or in darkness is required, the flare would be useful if dark adaptation can be achieved in time. From the crew safety standpoint, the hazards of carrying on board 100 pounds of explosive material and setting off a 15 megawatt flare 100 feet from the spacecraft would have to be carefully weighed against illumination advantages.

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BIBLIOGRAPHY

1. Note that the present constraints imposed by good surface contrast illumination require that the sun be behind the LEM making an angle with the horizon of 7^{o} to 13^{o}, i.e., at least 4^{o} below the descent angle. (These constraints could be relaxed by a dog-leg approach using more fuel).

2. V. Hamza, "Lighting Conditions for a Lunar Landing Mission", Bellcomm Report, January, 1967.

3. V. Hamza, "Lunar Lighting Conditions for the Apollo Lunar Landing Mission", Bellcomm TM-66-1012-6, May 17, 1966.

4. "Lunar Surface Visibility", TRW Systems Report 05952-6011-R000, August 3, 1966.

5. V. Hamza and H. W. Radin, "Lighting and Approach Angle considerations for Manned Lunar Landings", Bellcomm TM-65-1012-13.

6. D. R. Anselmo and P. A. Cavedo, "Evaluation of Lunar Lighting Constraint Based Upon Photometric Derived Scene Contrast", Bellcomm TM-66-2013-1, April 29, 1966.

7. This oxidizing agent, (CTF), when burned with aluminum or beryllium, yields about three times the chemical energy per pound of TNT. It has been proposed as a candidate for a lunar flare for surface chemical analysis. In vacuum tests it has delivered about 1% of its energy as visible light during an explosion lasting a few milliseconds. See Douglas Report SM48082, December, 1964.

8. D. M. Johnson, "Proposed Kinetics and Mechanics of Illuminant Flares; Maximizing Efficiency" (Unclassified). U.S. Naval Ammunition Depot; Crane, Indiana, January 13, 1966. (Documentation Center, AD 627 649).

9. J. A. Carrazza, Jr., B. Jackson, Jr., S. M. Kaye, "New Flare Formulations for High Altitude Application". (Unclassified) U.S. Army, Picatinny Arsenal; Dover, New Jersey, October, 1966 Technical Report 3360 (Defense Documentation Center, AD 641957).